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The EUROPEAN CORN BORER

ITS PRESENT STATUS AND METHODS OF CONTROL

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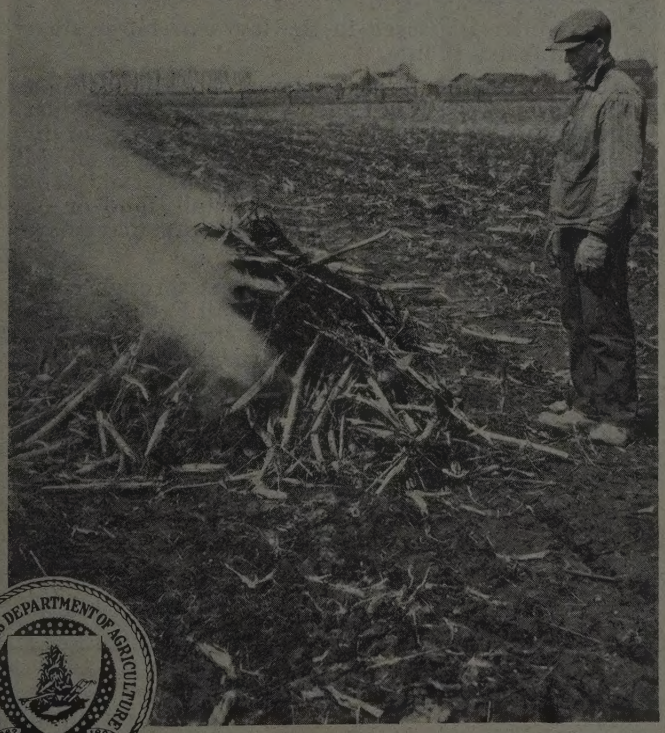

UNITED STATES DEPARTMENT OF AGRICULTURE
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THE EUROPEAN CORN BORER is the most dangerous enemy of Indian corn that has ever appeared in America. Its presence in the Corn Belt is a menace to the agriculture of that vastly important region. Unless vigorous efforts to control it are continued indefinitely by corn growers in the infested areas it will cause serious and widespread losses to the corn crop.

The caterpillars, or borers, tunnel through practically all parts of the corn plant and destroy or severely injure the stalks and ears. In the Middle West there is but one generation each year although in eastern New England two generations usually appear annually.

The winter is passed in the larva or borer stage within infested plants.

To suppress this pest, destroy all cornstalks, cobs, and refuse before May 1 each year by plowing under completely and cleanly, by burning cleanly, or by feeding to livestock directly from the field, as silage, or as finely cut or finely shredded material. The disking in of small grains on cornstalk land or on high-cut corn stubble is a dangerous practice where the corn borer is present.

To prevent the spread of the pest through commerce or artificial carriage, State and Federal quarantines are necessary and are strictly enforced. The hearty cooperation of all farm owners, tenants, and other interested persons is requested in overcoming this formidable pest. Most of the infested States have enacted legislation requiring compliance with the control program as outlined in this bulletin.

This bulletin supersedes Farmers' Bulletin 1294, entitled "The European Corn Borer and Its Control."

Washington, D. C. October, 1927

THE EUROPEAN CORN BORER:

ITS PRESENT STATUS AND METHODS OF CONTROL

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THE EUROPEAN CORN BORER[1] is a pest of foreign origin which has gained entrance to the United States. Probably it came in in shipments of broomcorn. The exact date of its arrival is unknown, but its presence in this country was first discovered in the summer of 1917.

Since its discovery in this country the best efforts of Federal and State agricultural authorities have been devoted to the task of retarding its spread and of devising methods for its control.

The results of nine years of study by the Bureau of Entomology, in cooperation with various State authorities, leave no room for doubt that the corn borer is one of the most injurious plant pests that has invaded this country. Furthermore, unless the recommended measures for its control are strictly and universally adopted in areas at present infested by the pest, the serious and widespread losses to the corn crop now prevalent in Europe and in Ontario, Canada, are very likely to be repeated in the important corn-growing areas of the United States.

[1] *Pyrausta nubilalis* Hübn.; order Lepidoptera, family Pyralidae, subfamily Pyraustinae.

Thus far, investigations have shown conclusively that the total eradication of the European corn borer in this country is beyond the realm of possibility. It has been found feasible, nevertheless, to reduce the numbers of the borers in any given area to such an extent, by improved farm clean-up methods and other cultural practices, that the damage by the insect will be kept below the point of serious commercial loss.

HISTORY OF THE CORN BORER IN THE UNITED STATES

When the European corn borer was reported and identified in 1917 it was found to be causing severe damage to sweet corn in the vicinity of Boston, Mass., and to be present within an area of at least 100 square miles in that section.

In January, 1919, the insect was discovered in the vicinity of Schenectady, N. Y., and in September, 1919, separate infestations were found south of Buffalo, N. Y., and at Girard, Pa.

The summer scouting of 1921 revealed an infestation of the pest on Middle Bass Island in Lake Erie, not far from the Ohio shore. Subsequent investigations during 1921 and 1922 showed that a sparse but extensive infestation by the European corn borer had developed throughout a narrow strip of territory comprising most of the townships bordering Lake Erie, and adjacent thereto, in the States of Michigan, Ohio, Pennsylvania, and New York.

During the late summer of 1923 a small area of infestation was discovered at Brooklyn, N. Y. Limited infestations were also found during the period from 1924 to 1926 on Staten Island, N. Y., and in scattered townships in Connecticut along the shore of Long Island Sound. Two small, independent infestations were found in the Bayonne and Jersey City sections of New Jersey.

In the late season of 1926 the corn borer was found to have entered northeastern Indiana; a single specimen of it was found in Yellow Head Township, Kankakee County, Ill., and a few specimens of the pest were discovered in the township of Galien, Berrien County, Mich.

DISTRIBUTION IN NORTH AMERICA

IN THE UNITED STATES

At the close of 1926 the European corn borer was known to be present and well established throughout two large separate areas of the United States shown on the map (fig. 1), as well as in the isolated areas just described, comprising a total area of approximately 93,000 square miles.

To determine whether the borer was present in any other areas very extensive scouting operations have been carried on each year since 1920 in the territory surrounding and adjacent to the known-infested States, as well as along the main lines of travel, river valleys, water routes, in the vicinity of broom factories, and in other localities likely to be infested. These operations have included field examinations in all localities likely to be infested east of the western boundary of Nebraska, and in Texas, New Mexico, and Arizona.

Particular attention has been given to localities where imported broomcorn was known to have been received, to localities where seed corn on the cob had been purchased from eastern dealers, to corn-canning districts, and to sections producing field corn, sweet corn, and broomcorn. Special scrutiny has been given the territory adjacent to ocean and river ports, as well as to railroad centers, and along the main railroad, highway, and water routes.

IN THE DOMINION OF CANADA

During August, 1920, the Canadian authorities reported the discovery and identification of the European corn borer in Welland

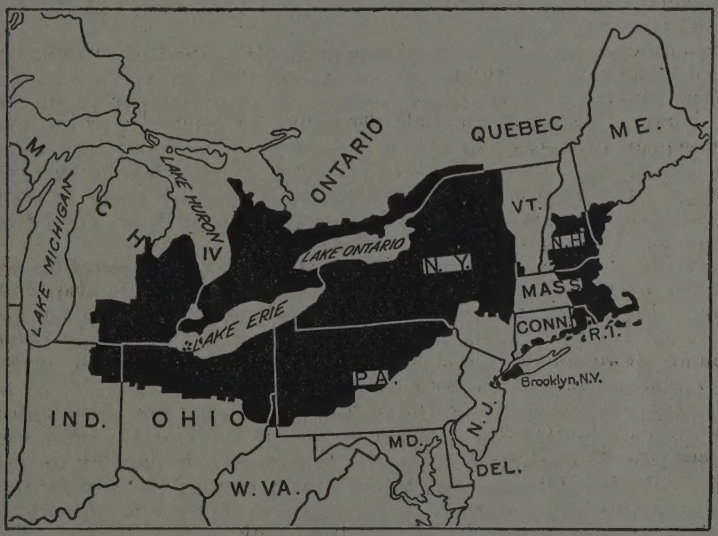

FIG. 1.—Areas in the United States quarantined on account of the European corn borer up to January 1, 1927. Small areas of infestation in Connecticut and in the New York Bay region are indicated, as well as the approximate limits of the area infested by the corn borer in Canada

County, Ontario, across the Niagara River from the western New York area of infestation, and another large and heavily infested area extending along the Canadian shore of Lake Erie with its apparent center near St. Thomas, Ontario.

At the close of 1926 the Canadian authorities reported the European corn borer to be present throughout most of the southern Ontario peninsula, bordering Lake Erie and Lake Ontario and extending along the St. Lawrence River to a point in the Province of Quebec, just across the provincial line. (Fig. 1.) The greater part of the area infested by the corn borer in Canada is contiguous to the infested areas of the United States, which resolves the matter of controlling this dangerous pest into a problem of international scope.

HOW THE CORN BORER REACHED THE UNITED STATES

The exact date and the manner in which this dangerous European pest gained entrance to the United States is not definitely known, but circumstantial evidence accumulated since its original discovery in New England indicates strongly that broomcorn which was imported for manufacturing purposes from Hungary or Italy during the period from 1909 to 1914 was the probable means of entrance. Broom factories which received this foreign material were located near the apparent centers of infestation at Everett, Mass., and Amsterdam, N. Y. Broomcorn is known to be commonly infested by the corn borer in both Hungary and Italy, where much of this material originated. The inspection service at points of entry was not authorized by law until 1913, or subsequent to the entry of the corn borer into this country.

An apparent confirmation of this probable method of introduction was afforded during February and March, 1920, in April, 1922, and again in March, 1923, when commercial shipments of broomcorn from Hungary and Italy were intercepted by inspectors of the Federal Horticultural Board at the port of New York and were found to contain many living larvae of the pest. During March, 1923, the inspectors also intercepted living larvae of the corn borer in stalks of broomcorn in passengers' baggage arriving at New York from Italy and Germany.

From present indications it is believed that the original infestations by the corn borer on the islands and along the shore of Lake Erie in Michigan, Ohio, Pennsylvania, and western New York may have originated from the badly infested area just across Lake Erie, in the Province of Ontario, although no conclusive proof of this assumption has been established. The history and intensity of the Canadian infestation indicate that it is probably the oldest colony of the pest in this region. The origin of the Ontario infestation is thought by Canadian authorities to be traceable possibly to large importations of broomcorn into Ontario during the period from 1909 to 1910, although there is no conclusive evidence to support this opinion.

The borer may have spread from Ontario through the flight of the moths or through the drift of infested plant material in the waters of Lake Erie. A study of the wind and water currents in the Lake Erie section, as well as of the known habits of the corn borer, shows the possibility of the borer's spread through either of these agencies.

CORN IS THE FAVORITE HOST OF THE CORN BORER IN THIS COUNTRY

Corn is infested and injured (fig. 2) by the larvae, or borers, of the European corn borer to a greater extent than any other crop attacked by the insect in this country. The borer attacks field corn (both dent and flint), sweet corn, pop corn, and corn planted for fodder or silage. Judging from all experiments and observations extending over a period of nine years it appears that corn, in general, is the favorite host of the insect in North America, as it is in Europe.

IN THE MIDDLE WEST

In the Middle West corn was practically the only plant that had been injured or infested to any extent by the corn borer up to the end of 1926. A light infestation has been found in some of the more common large-stemmed weeds and grasses growing among the corn or along the margins of badly infested cornfields. Careful examinations under these conditions have revealed the presence of the borer in important numbers in pigweed,[2] smartweed,[3] cocklebur,[4] barnyard grass,[5] lamb's-quarters,[6] foxtail,[7] panic grass,[8] and similar plants.

The fact should be emphasized that these corn-borer infestations in weeds in the Middle West at present are confined to infested cornfields or their margins and are usually caused by the borer seeking shelter in such plants. No instances of corn-borer infestations in weeds growing at a distance from corn have been observed to date, although special and extensive examinations have been made to determine this point.

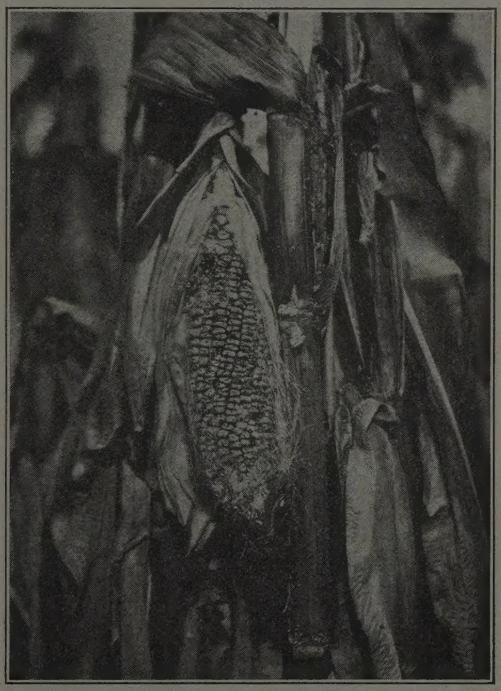

FIG. 2.—"Close-up" of ear and stalk of dent field corn, showing typical injury by the European corn borer

Under conditions of favorable exposure in western New York a light infestation has been observed in some of the cultivated crops and flowering plants, including broomcorn, soy beans, millet, buckwheat, sorghum, dahlia, and cosmos. The number and variety of weeds and cultivated crops infested by the corn borer in the Middle West will probably increase in the future unless a general attempt is made to reduce the number of corn borers by the recommended clean-up measures, to a point where such borers as survive will be confined for the most part to corn.

Several other kinds, or species, of native borers very similar in appearance to the European corn borer are found frequently in corn, vegetables, field crops, flowers, shrubs, weeds, etc. These native

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[2] Species of Amaranthus.
[3] Species of Polygonum.
[4] Species of Xanthium.
[5] *Echinochloa crus-galli* L.
[6] Species of Chenopodium.
[7] Species of Chaetochloa.
[8] Species of Panicum.

borers are often mistaken for the European corn borer and are the cause of much needless alarm and many erroneous reports. (See discussion under caption "Caterpillars often mistaken for the European corn borer," p. 42.

PLANTS INFESTED BY THE CORN BORER IN NEW ENGLAND

In New England corn also is the favorite host of the corn borer, but in this section the pest commonly attacks many other plants also, including vegetables, field crops, flowers, and weeds. Rhubarb, beet, celery, bean, pepper, oat, millet, dahlia, aster, gladiolus, chrysanthemum, zinnia, cosmos, hollyhock, and many different kinds or species of large-stemmed weeds or grasses are often injured severely by the corn borer in this section. In fact, at the close of 1926 a total of 224 kinds or species of plants in New England had been found to be infested with the corn borer. Many of these plants serve as shelter for the borers, rather than as food, and are infested sometimes by the borers which "overflow" from corn and other favorite host plants growing near by.

FIG. 3.—"Close-up" of hill of sweet corn ruined by the European corn borer. Stalks cut open to show work of borers within. An average of 37 borers was found in each plant in this field

The reason why more numerous kinds of plants are more commonly and severely infested by the European corn borer in New England than in the Middle West is not known definitely, but it is believed to be due principally to the fact that in New England the corn borer has two generations or broods each year, while in the Middle West only one generation or brood develops each year. In the region of two generations the rate of multiplication and consequent congestion of population, and the fact that the second brood of caterpillars find corn in a tough and unattractive condition, may account for the large number of plant species attacked.

CHARACTER OF INJURY CAUSED BY THE CORN BORER

The European corn borer, as its name implies, is essentially a boring insect and causes its most important injury to corn by the tunneling and feeding of the larvae or borers within the stalks (fig. 3) and ears (fig. 4). The borers also tunnel within the tassel, the midrib of the leaf, the brace roots, the stubble, and in fact in practically all parts of the corn plant except the fibrous roots. In addition they also feed to a slight extent upon the surface of the plant, particularly upon the leaf blades (fig. 5), the tassel buds, the husks, and silks of the ear, and between the leaf sheaths and the stalk.

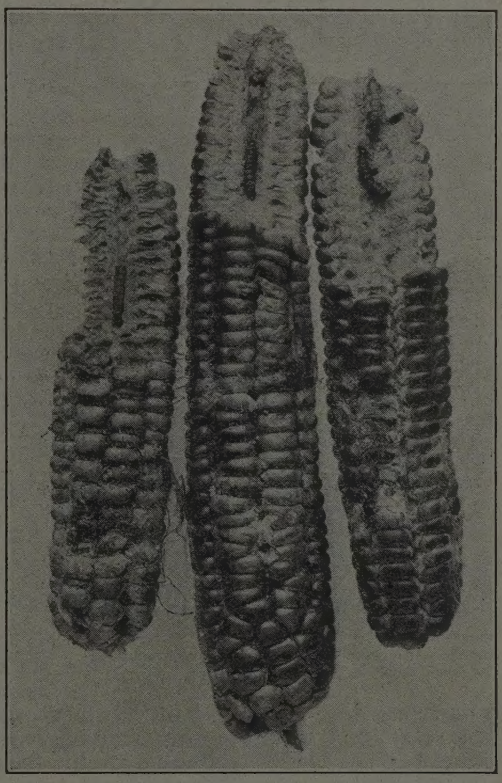

FIG. 4.—European corn borer injury to grain and cob of flint field corn. Cobs cut open to show borers within. One hundred per cent of ears and stalks were infested in the field in which these ears were harvested

The character of the injury to corn depends upon the stage of development of the plant when attacked and also upon the habits of individual borers. Usually, however, the newly hatched borers feed for a short period upon the surface of the plant, near their place of hatching, particularly upon the tender leaf blades (fig. 5), or upon the green silks and husks of partially developed ears. Within a few hours after hatching many of the borers begin to migrate to various parts of the same plant or to other plants in the vicinity. If the attacked plant is just developing a tassel, some of the small borers enter the tassel buds and feed within, while others feed on the surface of the tassel buds and protect themselves with a slight silken web.

As the tassel develops and the feeding borers become larger they tunnel within the tassel stalk and its branches. This injury so weakens the tassel stalk that it frequently breaks over. These broken tassels (fig. 6), with bunches of sawdustlike material at the breaks, are the most conspicuous signs of corn-borer infestation in fields of

growing corn, although many corn plants infested by the corn borer may not show this particular injury.

After working in the tassel stem the borers may continue tunneling downward into the main stalk, or they may leave the upper part of the plant and enter it or neighboring plants at points lower down, gradually increasing the size of their tunnels as they grow larger and working downward or upward, according to their individual preferences. Small holes in the plant (fig. 7), with bunches of sawdust-like material at or below the holes, indicate the point at which the borer is at work.

Instead of feeding upon or within the tassel buds and tassel stalks some of the newly hatched borers move to points lower down on the plant. Under these circumstances they may enter the plant at practically any point, but they usually enter between the leaf sheath and stalk (fig. 7) or between the stalk and the base of the partly developed ear (fig. 8), in case the plant has advanced to that stage of development.

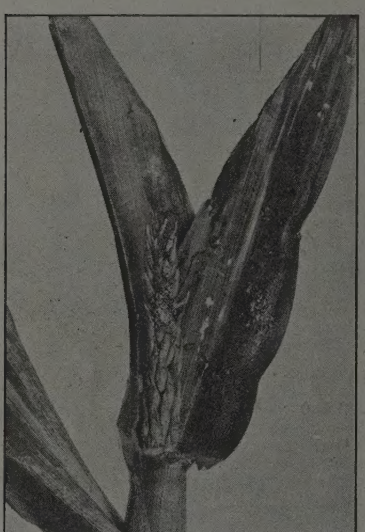

FIG. 5.—Injury to leaf blades and tassel buds of corn by young corn borers

The tunneling of one or two borers in a stalk does not always cause appreciable damage; but in cases where several or many borers are present within the same stalk, as frequently occurs, it becomes reduced to a mere shell and is filled with fragments of the frass or castings of the borer. Such injury may cut off much of the supply of nutriment from the developing ear and greatly weaken the stalk, which eventually collapses and breaks over.

It is evident that the injury to the stalk may indirectly affect the development of the ear by interfering with the supply of nutriment, such injury depending, of course, not only upon the stage of development of the ear during the worst period of injury but also upon the extent of injury to the stalk. In instances of severe infestation, at least, the greater part of the grain loss caused by the corn borer may be charged to this indirect injury to the ear.

The ear may be entered directly by the borers (fig. 8) at any stage of their development, at its tip, base, or side, or it may be entered indirectly through the short stem or shank by which the ear is attached to the stalk. Ordinarily the ear is entered at its tip (fig. 9) by small borers which feed first upon the silk, or the tender portion of the husk, and then work their way down into the cob and grain (fig. 10).

Injury to the ear stem or shank, when severe and occurring early in its development, may interfere with the supply of nutriment to

the ear. Moreover, the ear stem is frequently so weakened by such injury that it breaks over before the ear completes its development. Many ears thus affected fall to the ground long before harvest and are thus exposed to rots and other destructive agencies. (Fig. 11.)

The injury to stalks and ears by the corn borer may be still further increased by a soft rot which sometimes follows the work of the borers and reduces the interior of infested plants to a decaying, putrid mass, thus sometimes entirely destroying their feed value. This rot often causes greater loss than is occasioned primarily by the work of the borers.

FIG. 6.—Corn tassel broken over as a result of injury by the European corn borer. Castings of the borer at breaks, and tassel stem tunneled by the borer

CHARACTER OF INJURY TO PLANTS OTHER THAN CORN, IN NEW ENGLAND

Mention has been made of the fact that plants other than corn are commonly and severely infested by the corn borer in New England. The remarks under this heading therefore apply only in New England.

The injury to plants other than corn is of the same general character as that to corn, except that in some instances special parts of the plants appear to be preferred as food or shelter.

The stems or stalks of celery, rhubarb, potato, hop, oat, barley, buckwheat, hemp, cotton, dahlia, chrysanthemum, gladiolus, aster, zinnia, cosmos, geranium, and others are entered and tunneled by the borers, and the borers are sometimes found in the fruits or flowers of certain plants, notably tomato, pepper, cotton, hemp, dahlia, chrysanthemum, and gladiolus.

The stem and leaves of beet, spinach, Swiss chard, and other plants are preferred by the borers when attacking these plants.

In beans the borers are usually found in the stalks, pods, or green beans. The roots of beets are entered frequently.

Not only do the borers cause actual loss by their injury to these crops, but there is also the likelihood that such products, when distributed through commerce, may serve as carriers of the pest to new localities. This applies only to the New England section.

Injury to the weeds and wild grasses serving as hosts of the European corn borer in New England is not of itself commercially

FIG. 7.—Appearance of cornstalk showing outside evidence of the work of the European corn borer

important, but the presence of such weeds and grasses affords abundant opportunity for the multiplication and spread of the pest

throughout areas where corn is not grown. In cultivated fields the borers are sometimes so numerous that they are compelled to feed upon these other plants in order to complete their growth. There is also a possibility that some of these wild plants, when used for packing material or as bedding, may contain the borers and thus become a medium for transporting the pest to new localities.

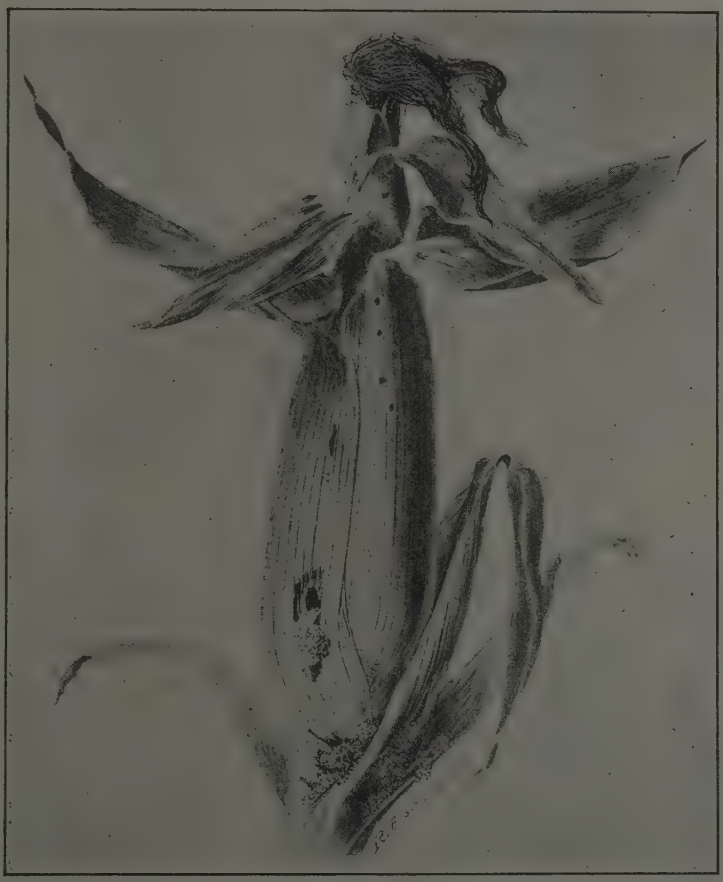

FIG. 8.—Outside view of ear, showing entrance of borer near base of ear and numerous punctures in husks through which borers have entered ear

DESCRIPTION AND SEASONAL HISTORY OF THE CORN BORER

In the Middle West the European corn borer passes the winter as a fully grown borer or "worm" inside its tunnels in the stalks, stubble, or ears of corn, although it sometimes may pass the winter in weeds and other plant material growing close to corn. The presence of the borers may be detected easily by small holes on the surface of

infested plants. These holes are usually plugged with the castings of the borers. When these stalks, stubble, etc., are split open, the

FIG. 9.—Typical injury by the European corn borer to the grain and cob of flint field corn. The borers are shown feeding in natural position. The inside of the cobs was also badly tunneled by the borers

borers (fig. 12) usually are found within. At this time the borer is nearly an inch long and one-eighth of an inch thick. (Fig. 13.)

The head is dark brown or black. The upper surface of the body varies in color, from light brown to dark brown and to pink. Each

FIG. 10.—European corn borer injury to grain of dent field corn. The cobs and ear shanks were also badly tunneled by the borers. One hundred per cent of the stalks and ears were infested in this field

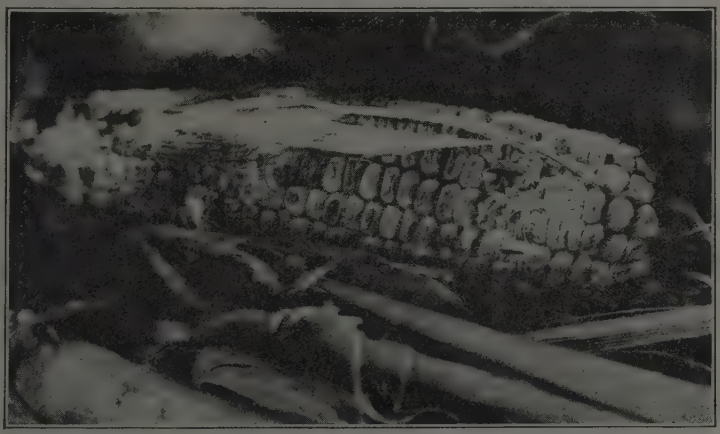

FIG. 11.—Injury to the ear stem or shank by the corn borer caused this ear of dent field corn to fall to the ground early in the season. Husks removed from ear to show rotting of grain and poor condition of ear

division of the body bears a row of small dark-brown spots, while several narrow dark-brown or pink lines extend lengthwise of the

body. The underside of the body is flesh color and is without markings.

As soon as warm weather begins in April or May, the borers resume their activities, although no real feeding takes place at this period. The fact should be repeated that no feeding takes place in the spring, although the borer may leave the shelter it occupied during the winter and bore into a more suitable piece of cornstalk or other shelter, preparatory to getting ready to go into the resting stage or pupa.

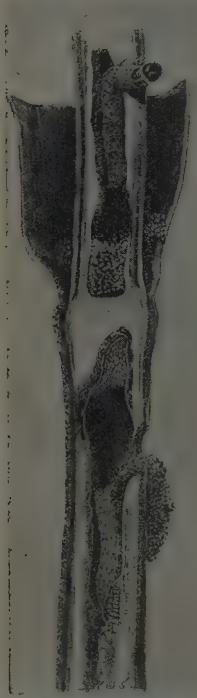

FIG. 12.—Cornstalk split open to show European corn borer within

In late May or early June the borer cuts a small circular opening from its tunnel to the surface of the plant in order to provide an exit for the future moth. It then closes this hole with a thin partition of silk and retreats into its tunnel to a point near the last feeding or shelter place, where it usually spins a thin cocoon. Inside this cocoon the borer changes into the resting stage, or pupa. (Fig. 14.) When the stalks, stubble, ears, etc., are split open the pupa may be found within.

The pupa, or resting stage, is shuttle shaped, light brown or dark brown, and from one-half to five-eighths of an inch in length. After a period of from about 10 to 14 days the skin of the pupa splits and the moth or adult comes forth. In the Middle West the moth or adult is present in the fields during late June, throughout July, and during early August, under average weather conditions.

The female moth (fig. 15) has a robust body and measures about an inch from tip to tip of the wing. The general color is variable and represents all shades from pale yellow to light brown. The outer thirds of both the forewing and the hind wing are usually crossed by two narrow zigzag lines darker than the rest of the wing. The male moth (fig. 15) has a longer, more slender body, is slightly smaller in wing expanse, and is usually much darker than the female. The general color varies from pale brown to dark brown, sometimes with a blue tinge. The outer third of the wing is usually crossed by two narrow zigzag streaks of pale yellow and there are frequently small pale yellow areas on the forewing.

FIG. 13.—Borer stage of the European corn borer. About natural size

The moths of the European corn borer resemble several other kinds or species of moths so closely that it is difficult if not impossible for the average person to distinguish between moths of the corn borer and those of the other species which closely resemble it.

The moths are strong fliers. Experiments have shown definitely that they are able to fly for a distance of at least 20 miles, and judging from their general habits it is probable that they can and do fly for greater distances. Large bodies of water do not check their flight, as the moths have been seen to alight on the surface of the water and again take flight. Experiments have also shown that the moths were able to reach cornfields surrounded by high hills or woodlands. During windy periods flight is usually in the direction of or with the wind.

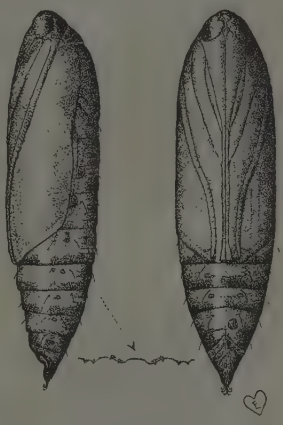

FIG. 14.—Resting stage, or pupa, of the European corn borer. About three times natural size

Soon after emergence the moths mate and begin to lay eggs. They remain quiet during the day, hiding in patches of weeds and grass or underneath the leaves of other plants. During the early evening and early morning they fly from plant to plant, laying their eggs in flat, irregularly shaped masses. (Fig. 16.) There usually are from 15 to 20 eggs in the average egg mass. Although eggs deposited singly may be observed, as many as 162 eggs have been found in a single mass. These egg masses are laid principally upon the underside of the corn leaves, although they are sometimes laid on the upper side of the leaves, on the stalk, or on the husk of the ears. Each egg is about half the size of an ordinary pinhead and overlaps the next egg in the manner of a fish scale.

The female moths lay an average of about 400 eggs each, although the number varies greatly and experiments have shown them to be capable of laying from about 700 to over 1,900 eggs each. The moths live from 10 to 24 days.

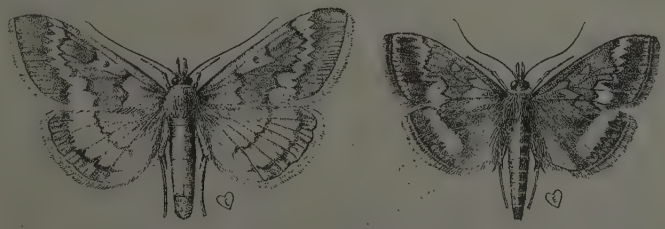

FIG. 15.—Moth or adult stage of the European corn borer. At left, female moth; at right, male moth. Not quite twice natural size

The egg is nearly flat and is white when first laid, but later changes to pale yellow, becoming darker just before the young borer hatches. By closely examining the under surface of corn leaves it should be possible for any person to find these egg masses in fields where the moths are numerous.

The eggs hatch in from four to nine days, depending upon weather conditions. The newly hatched borer is about one-sixteenth of an

inch long, with a black head and a pale yellow body, bearing several rows of small black or brown spots. It feeds for a few days upon the surface of the leaf, near its place of hatching, but soon enters the plant and completes most of its development therein. It may also move to other plants in the vicinity by crawling or by spinning a suspending thread.

During its growth the borer changes its skin or molts five or six times, gradually increasing in size with each change until at last it is in the same stage as the overwintering borer previously described.

In the Middle West most of the borers become nearly full grown by the middle of August, during a season when the weather conditions are normal. The borers continue to feed at intervals until cold weather stops their activities in October or November. They remain in a dormant condition within their tunnels in cornstalks, corn stubble, corncobs, and other plant remnants throughout the winter.

In New England the seasonal history of the corn borer is different from that just described in the Middle West. In New England the corn borer has two broods or generations each year. In this section the overwintering borers enter the resting stage in late April and in May. The moths emerge from the resting stage in June and the eggs laid by these moths develop into fully grown borers in a period ranging from 30 to 40 days, depending upon weather conditions. They become fully grown during the period from the middle of July to early August, and then enter a short resting or pupal stage. The moths emerge from this second-brood resting stage during August and early September. The eggs laid by these second-brood moths hatch into borers which develop in the same manner as described for the first-brood borers. They become full grown before the appearance of cold weather and pass the winter in a dormant condition within cornstalks, corn stubble, and corncobs, and in the stems of a great variety of vegetables, flowers, weeds, and large-stemmed grasses. The description of each stage of the corn borer (egg, borer, pupa, moth) in New England is also the same as for those stages in the Middle West.

FIG. 16.—Egg stage of the European corn borer. Eggs somewhat enlarged

EXTENT OF CROP LOSS CAUSED BY THE CORN BORER

IN THE MIDDLE WEST

In the worst-infested parts of northwestern Ohio and southeastern Michigan severe economic loss caused by the European corn borer occurred for the first time during 1926. In a few cornfields of this section the estimated crop loss to dent (field) corn and sweet corn ranged from 25 to 40 per cent in the worst-infested fields. With the exception of these few cornfields there was very little noticeable

economic loss caused by the corn borer in Michigan, Indiana, Ohio, and Pennsylvania up to the close of 1926.

In western New York during 1926 an increase of the infestation occurred and the estimated commercial loss exceeded 25 per cent in many of the fields of dent corn grown for grain in the older portion of the infested area centering around Silver Creek. In this same district the loss in sweet-corn ears for canning in 1926 reached about the same figure.

The rapid spread of the corn borer into new territory of the Middle West during 1925 and 1926 was accompanied by a great increase in the numbers of the borers all through the area now occupied by the pest. Careful field examinations in the corn-borer-infested areas of Michigan, Ohio, Pennsylvania, and western New York during the late summer and early fall of 1926 showed that there were nearly four times as many borers present as there were at the time a similar examination was made in 1925. The exact rate of increase was 280 per cent.

Should the rate of increase in numbers of the borers which occurred during the years 1923 to 1926 be continued, it is feared that the crop losses now being suffered in the oldest infested fields of the Middle West and in the neighboring Province of Ontario, Canada, as well as in Europe, will become general in the near future throughout the great corn-growing region of the Middle West, unless the recommended control practices are strictly and universally followed.

IN CANADA

Since the summer of 1923 the corn-borer situation in southern Ontario, Canada, just across Lake Erie from New York, Pennsylvania, and Ohio, and adjacent to Michigan on the west, has rapidly grown worse. At the close of 1924 the Canadian authorities reported that commercial losses occurred in 21 townships of that section, where the proportion of cornstalks infested by the corn borer ranged from 50 to 100 per cent. At the close of 1925 the Ontario infestation had become so serious in the counties of Essex and Kent, where the best dent (field) corn in the Dominion of Canada had formerly been grown, that the corn crop throughout an area of at least 400 square miles was completely ruined. (Fig. 17.) Control measures were adopted very slowly by growers, since there existed at that time no compulsory clean-up laws. This situation in Ontario became worse in 1926, when it was found that in an area of about 1,200 square miles the corn acreage had been reduced to about 10 to 15 per cent of the land used for that purpose during 1922. This reduction in acreage, of course, was due to the severe damage done to the corn crop by the corn borer during the years 1924 to 1926. In this area of severe corn-borer damage many fields showed a loss of the entire crop and losses of 75 per cent were common. A provincial compulsory clean-up law, requiring the farmers of Ontario to clean up their fields, became effective October 1, 1926. In the meantime the corn-borer infestation in Canada had progressed eastwardly, completely surrounding Lake Ontario and joining with the infested area in New York.

IN NEW ENGLAND

In the corn-borer-infested region of New England the crop losses and degree of infestation have decreased very greatly since the Massachusetts clean-up laws became effective in 1922. Great decreases were especially noticeable in the large and valuable areas of market-garden sweet corn where an average of 20 per cent ear infestation in 1922 had been reduced to less than 5 per cent in 1926. Similar reductions in crop losses and infestation had occurred in susceptible vegetables, field crops, and commercially grown flowers. A remarkable decrease has been brought about in the number of corn borers existing in the large weed areas of that section. Formerly many millions of corn-borer moths issued from these weeds to lay their eggs upon cultivated crops but this source of danger has been removed as a

FIG. 17.—A field of dent field corn ruined by the European corn borer. Ontario, Canada, 1926

result of the enforcement of the Massachusetts law requiring clean-up action and of the experience of the farmers who have learned the necessity of clean culture in fighting the corn borer.

A careful examination of cornfields in the New England area during the season of 1926 showed that the number of borers had decreased 94 per cent since 1922 when the Massachusetts clean-up law went into operation. This means that there were only about one-sixteenth as many borers in the cornfields during 1926 as there had been during the height of the infestation and damage in New England during 1922.

IN EUROPE

The European corn borer has long been recognized in Europe and Asia as one of the worst pests attacking corn, millet, hops, hemp, and similar crops. European entomologists have recorded many instances of severe crop losses caused by the insect, particularly of corn in the corn-growing region of Hungary, where during certain years, according to European writers, the losses to the corn crop have ranged from 25 to 50 per cent over large areas. Conditions in this Hungarian region resemble closely in many respects those prevailing in the Corn Belt of this country.

In addition to losses of corn, severe losses of millet, hemp, and hops from corn-borer injury are also reported by European authorities.

During the period from 1924 to 1926 representatives of the Bureau of Entomology have been studying the European corn borer in the principal corn-growing districts of central Europe. These studies showed that the corn borer was causing severe damage in some parts of Europe, particularly in southern Hungary and parts of Jugoslavia and Rumania. In these districts the losses to the corn crop ranged from about 5 per cent to nearly 25 per cent in the different localities where the investigations were made. Smaller losses were observed to crops of millet, hemp, broomcorn, and grain sorghum. In other parts of Europe, particularly in northern Italy and southern France, the corn borer is considered a pest of first importance, since it has caused severe losses in these districts in the past, although it was not present in large numbers during the seasons of 1924 to 1926, inclusive. Many reports have been received concerning the damage caused by the corn borer to corn, millet, and other crops in Russia, but owing to conditions there it was not possible to investigate the insect in that country.

In general it was found that the corn borer seldom caused severe damage in the European areas, in which farm practices were of such a nature that all corn remnants and other crop remnants infested by the corn borer were customarily destroyed by burning or plowing, or by using such remnants for feed or fuel. In areas in which the farm practices were such as to leave large quantities of corn remnants on the farms from year to year, as is now commonly done in the American Corn Belt, however, the corn borer caused severe losses at periodic intervals.

NATURAL ENEMIES OF THE CORN BORER

Although quite a variety of native natural enemies of the European corn borer have been recorded in this country, they do not usually attack the pest in any important numbers, and, from present indications, can not be relied upon to hold the corn borer in check.

INSECT PARASITES

Popular belief leads many persons to suppose that all destructive plant pests may be overcome by introducing or encouraging their natural enemies, especially their parasites. This method has been used with success in campaigns against some insect pests and is being given a very thorough test as a part of the effort to curb the European corn borer.

Extensive studies of the native insect parasites of the corn borer in the Middle West have shown that less than 1 per cent of the borers were being destroyed in this manner by three kinds or species of parasites. In a similar manner it has been found that less than 1 per cent of the borers, on an average, were killed by native parasites in the New England area of infestation, although 18 different kinds of four-winged parasites and 6 kinds of two-winged parasites were at work upon the corn borer in that section. During certain favorable years a small wasplike parasite [9] destroys considerable numbers of the corn-borer eggs, but the importance of its beneficial activities varies so greatly from year to year that it can not be relied upon.

FIG. 18.—One of the foreign parasites of the European corn borer. This parasite, *Exeristes roborator*, has been liberated in the infested areas of America and is now multiplying in the Great Lakes region and in New England. Note the long egg-laying organ of this female parasite. About four times its natural size

Since the native insect enemies of the corn borer have proved of little consequence, it seemed important to investigate the foreign parasites which were preying upon the corn borer in its native home, particularly in France, Italy, Belgium, and Hungary. As a first step, however, it was necessary to make careful studies of such parasites in the countries mentioned. These studies revealed several kinds of parasites that were helping to check the ravages of the pest. After it was determined that none of them could by any chance become harmful to plants, they were sent to the United States and, after proper handling, were liberated in cornfields where the corn borer was most numerous. Special precautions were taken, of course, to prevent the escape of natural enemies of the parasites (known as hyperparasites) when the beneficial parasites were liberated in this country.

[9] *Trichogramma minutum* Riley.

Up to June 15, 1927, 503,000 of these parasites had been liberated in the corn-borer-infested areas of Michigan, Indiana, Ohio, Pennsylvania, and western New York. (Fig. 18.) Nine distinct kinds, or species[10] were used in this work and these were liberated at twelve different places in the States mentioned. The places at which these parasites were liberated were chosen after very careful investigation to determine the localities in which they were likely to find the most favorable surroundings. Definite evidence has been obtained that some of these parasites became established in western New York during the period from 1924 to 1926, in Ohio during 1925 and 1926, and in Michigan during 1926. It is believed that the others will soon become established in other localities. Less than 1 per cent of the borers, on an average, are being killed at the present time by these parasites, but it is hoped that in time this rate of parasitism will increase.

Similar work in New England has resulted in placing about 1,300,000 parasites in infested cornfields of that section up to June 1, 1927. Ten different kinds, or species,[11] were used in New England and six of these species are known to be at work destroying the corn borer in that area.

PARASITES CAN NOT HARM PLANTS

It should be understood that none of these parasites can, through any chance, become harmful to plant growth.

PARASITES CAN NOT BE DEPENDED UPON TO CONTROL THE BORER

Although strenuous efforts are being made to import and establish parasites in the Middle West, and in the other American areas infested by the corn borer, it is by no means certain that they will prove to be effective aids in controlling the corn borer. Even with the best of success, several years may elapse before any important effect can be expected. In the meantime every effort should be made to control the corn borer by the practical methods discussed later in this bulletin.

PARASITE CONSERVATION CAGES

In order to aid in the conservation and spread of the foreign parasites of the corn borer 10 large cages have been built in the Middle West, 3 cages in the worst-infested area of Michigan, 3 in Ohio, 2 in Pennsylvania, and 2 in western New York.

These cages (fig. 19) are covered with copper screen having 18 meshes to an inch. They are 99 by 99 by 7 feet in dimensions. Each cage is large enough to provide for the shocking of all cornstalks grown on from 10 to 12 acres of infested fields. All parasites emerging from these cornstalks fly to the screen sides of the cage where they are collected and reliberated at suitable places within the area infested by the corn borer.

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[10] *Exeristes roborator* Fab. (fig. 18), *Microgaster tibialis* Nees, *Microbracon brevicornis* Wesm., *Eulimneria crassifemur* Thom., a species of Apanteles, *Angitia punctoria* Roman, *Phaeogenes planifrons* Wesm., *Zenillia roseanae* B. B., and *Masicera senilis* Rond.

[11] The nine species mentioned in the Middle West and *Macrocentrus abdominalis* Fab.

The tight construction of the cages and their covering of fine mesh copper screen prevent escape to the fields of the corn-borer moths which emerge from the cornstalks within the cage.

BIRDS

With the exception of somewhat local feeding by woodpeckers, birds are not known to have an important influence in reducing the numbers of the corn borer in the infested areas of the United States. In some of the small garden areas in New England the downy woodpecker[12] has been known to destroy from 17 to 95 per cent of the borers contained in the cornstalks. Woodpeckers have also been observed occasionally removing and devouring corn borers from cornstalks in the areas of the Middle West.

FIG. 19.—Parasite conservation cage. Infested cornstalks, containing corn-borer parasites, are placed in this cage. The parasites emerge and fly to the screen. They are then collected and liberated in cornfields infested by the European corn borer

Robins, grackles, blackbirds, starlings, crows, and Mongolian pheasants also are known to feed upon the corn borer. Careful observations in connection with plowing experiments in Ohio showed that robins and other birds were devouring at least 15 per cent of the borers which had crawled back to the soil surface after infested cornstalks had been plowed under. The Canadian authorities report that crows removed and devoured about 25 per cent of the corn borers from broken-over cornstalks in certain badly infested fields of Essex and Kent Counties, Ontario, during the winter and spring.

THE FEDERAL QUARANTINE AGAINST THE CORN BORER

The importation from foreign territory of plants likely to contain the European corn borer is regulated or forbidden by the terms of

[12] *Dryobates pubescens* L.

Federal quarantine No. 41, effective July 21, 1921. This is enforced by inspectors of the Federal Horticultural Board at all ports of entry throughout the country.

A domestic Federal quarantine, No. 43, on account of the European corn borer became effective on and after March 29, 1920. Various amendments have been made since that date. This quarantine is enforced by the Bureau of Entomology in cooperation with the Federal Horticultural Board and the various States affected.

In the one-generation area, extending from the western edge of Vermont westwardly to Indiana, the quarantine includes corn, broomcorn, sorghum, and Sudan grass. The chief effort is directed against the transportation of corn on the cob from the quarantined area to points outside thereof, because ears of corn often are dangerously infested. In maintaining this quarantine, inspectors are stationed on all main highways leading out of the quarantined area and are instructed to stop all vehicles in order to ascertain if they are carrying corn on the cob.

In addition to the quarantined products previously mentioned, shelled corn has recently been included in quarantine No. 43. The requirements for certification of shelled corn are that it be free from all parts of the cob. This should insure its leaving the quarantined area free from any infestation of the European corn borer and thus make it safe for movement to outside points.

The railroad, steamboat, and other transportation agencies are frequently visited by inspectors in search of possible violations of quarantine No. 43. Dining cars are forbidden to carry roasting ears through or out of infested areas.

If good cooperation in observing the regulations regarding the transportation of quarantined products can be secured from all concerned, commercial spread can be reduced to a minimum.

In the New England area the quarantine includes corn, broomcorn, sorghums, and Sudan grass, cut flowers or entire plants of chrysanthemum, aster, cosmos, zinnia, and hollyhock, and cut flowers or entire plants of gladiolus and dahlia, except the bulbs thereof, without stems, and applies throughout the entire year. To celery, green beans in the pod, beets with tops, rhubarb, and oat or rye straw, the quarantine applies only from June 1 to December 31 of each year. Chrysanthemums and gladioluses may be heavy carriers of the corn borer in the New England area, and often are shipped long distances. The greater number of plants included in the New England quarantine, as compared to the plants included in the quarantine for the one-generation area farther west, is due to the greater variety of plants commonly infested by the corn borer in the two-generation area of New England.

The area quarantined on account of the European corn borer in New York, Pennsylvania, Ohio, Michigan, Indiana, and West Virginia comprised 87,325 square miles at the close of 1926. In New England a total area of 6,461 square miles is under quarantine. (See fig. 1.)

METHODS OF CONTROL IN THE MIDDLE WEST

Nine years of experience in fighting the European corn borer have shown that the pest may be effectively controlled by utilizing or

destroying all parts of infested plants each year before the borers develop from the worm stage into the moth or adult stage. Under practical farm conditions this means that infested plants must be disposed of principally through any one of the following methods, or by a combination of such methods: (1) Feeding to livestock direct from the field, as silage, or as finely cut or finely shredded material; (2) plowing under cleanly; and (3) burning completely.

Under present conditions of corn-borer infestation in the Middle West the main control effort should be directed against corn, because it is practically the only plant directly attacked by the corn borer in that section. In the case of badly infested cornfields the clean-up should be extended to include large-stemmed weeds and grasses growing among the corn, or along the borders of such fields, because the borers often leave badly infested corn plants and enter near-by weeds or grasses for shelter or food.

Since the corn borer develops into the moth stage in the late spring or early summer, during the period beginning about the last week or 10 days of June in an ordinary season, it is plain that all infested corn plants and corn remnants should be disposed of before that date. To provide a proper margin of safety such disposal should be made before May 1 of each year.

Experience with corn-borer conditions has shown the desirability of making a special attempt to dispose of infested cornstalks and other corn residues in the fall, especially in fields which can not be plowed or otherwise handled effectively in the spring. This applies particularly to areas in which the rotation calls for seeding small grains in the spring and in which the character of the soil is such that it can not be successfully prepared for small grains or other crops after spring plowing.

Throughout the discussion of methods recommended for the control of the European corn borer it is recognized that many of the recommendations require a radical departure from present farm practice, but it should be recognized that under corn-borer conditions such changes are necessary, if the pest is to be controlled.

It is plain that the control of the corn borer is dependent upon a community-wide effort, because the moths are able to fly from field to field and thus to carry infestation for long distances. Therefore the moths emerging from a single unclean or poorly cleaned, infested field are sufficient to reinfest many other fields, even where precautions have been taken to dispose of all infested material in these fields.

Although the control efforts have included an extensive attempt to educate corn growers to the fact that the control of the corn borer is possible by the clean-up methods described in this bulletin, experience has shown that voluntary cooperation in clean-up methods can not be depended upon to secure results. It has been necessary, therefore, for the States of Michigan, Indiana, Ohio, Pennsylvania, New York, Massachusetts, and Maine to promulgate clean-up regulations to meet the emergency and to insure that the clean-up efforts shall be universal in the areas infested by the corn borer.

In summarizing the general control methods it should be emphasized that the particular method adopted is not important so long as the infested plants and the crop remnants are disposed of by feeding to livestock, or by plowing clean, or by burning clean, or by any

other method which secures their complete disposal. Each field presents a separate problem, and clean-up methods will naturally vary according to the type of farming practice used.

FEEDING INFESTED PLANTS TO LIVESTOCK

The feeding of corn-borer-infested plants to livestock is one of the most effective methods for fighting the corn borer and is also a most desirable farm practice. The food value of the fodder is not noticeably injured by the corn borer except in cases of very bad infestation. Infested corn plants may be fed as silage, or direct from the field, or in the form of finely shredded or finely cut fodder. When properly carried out, any of these methods results in the destruction of a very large part of the borers contained in the plants.

FIG. 20.—Corn stubble split open to show corn borers in lower part of stubble. This illustrates the necessity for cutting the cornstalks close to the ground. Arrows point to the corn borers

To obtain best results with the silo, under corn-borer conditions, the infested plants should be cut as close to the ground and as early in the season as possible. Experiments have shown that any borers which escape the silage cutter are destroyed in the silo.

Special experiments with silage cutters of various types show that infested cornstalks must be cut into pieces not more than one-half inch long to insure that practically 100 per cent of the borers are killed by the machine. This precaution is particularly important in instances in which for any reason the silage is not placed directly in the silo or is not fed soon after treatment.

Special low-cutting attachments for corn binders are now available from some of the larger implement manufacturers and their use is strongly recommended. Experiments have shown that at least 3 per cent of the borers are left in stubble 3 inches high when cornstalks

are cut during the middle of September and that at least 7 per cent of the borers are left in 6-inch stubble of cornstalks cut on the same date. The number of borers in stubble (fig. 20) of any given height increases about three times between the middle of September and the first week of November.

It is plain, therefore, that when the system of farming is such that the corn is to be cut, it should be cut as low and as early as possible. Such low cutting also helps in doing a clean job of plowing later on, or in any other clean-up method used.

In actual practice the use of short-handled, heavy hoes to cut corn has been found effective and practicable in instances where the corn was cut by hand. By this method the corn can be cut at, or very near, the surface of the ground. The use of hoes for cutting corn

FIG. 21.—A common source of reinfestation by the European corn borer: Remains of whole cornstalks fed direct to livestock in pasture and feed lot. These remnants should be raked into piles or windrows and burned

has come into increasing favor by farmers in the corn-borer-infested fields in the Great Lakes district, particularly in the smaller fields, and remarkably good clean-ups have been obtained by their use.

FEEDING DIRECT FROM THE FIELD

When infested cornstalks are fed direct (fig. 21) without previous cutting or shredding, the uneaten parts should be collected and destroyed, preferably by burning, unless they are trampled deeply into the manure.

It is dangerous to allow large quantities of cornstalks to accumulate in barnyards and feed lots (fig. 22) unless conditions are such that they are trampled deeply into manure. An examination of the cornstalks in barnyards and on the surface of manure piles of typical farms in Lucas County, Ohio, during the spring of 1927 showed as

many as 256 borers per 1,000 linear feet of cornstalks. No living borers were found in stalks buried deeply in the manure, or in finely cut or finely shredded corn fodder which had been used for feed or bedding.

HUSKER-SHREDDERS VERY EFFECTIVE IN KILLING BORERS

Shredding or cutting corn fodder into fine pieces, as is ordinarily done by husking and shredding machines, kills from 98 to 100 per cent of the borers and makes the fodder more acceptable to livestock. This result was obtained in tests with several types of husking machines, commonly termed "shredders," equipped with shredder-heads, or cutter-heads, or with combination shredder and cutter heads. The effectiveness of the machines was increased where special care was taken to apply sufficient pressure on the snapping rolls to produce a crushing effect and prevent long pieces of the fodder from

FIG. 22.—Barnyard feed lot containing infested cornstalks at the rate of 256 borers to every 1,000 feet of cornstalks. All dry parts of such cornstalks should be collected and burned unless trampled deeply into the manure

being whirled through the head without being finely cut or shredded.

Most of the borers that escaped death in the machine were found to have perished during the process of storing the shredded material, feeding it to livestock, and using the residue as bedding, finally to be trampled into the manure, as is the case in general practice.

This method of disposing of fodder is strongly recommended and its use, in corn-borer territory, should be greatly extended.

THE CUTTING BOX NOT EFFECTIVE

The cutting box as ordinarily used has not proved effective in killing borers contained in cornstalks. If used at all, it should be adjusted so as to cut the stalks in pieces not more than one-half inch long.

EFFECT OF COVERING OR TRAMPLING INFESTED CORNSTALKS IN MANURE

Frequent mention has been made in the preceding discussion of the effectiveness of trampling or covering deeply infested cornstalks in manure. Experiments on infested farms have shown in general that practically all corn borers perish when infested cornstalks or other corn remnants are covered by wet manure to depths ranging from 10 to 12 inches, or when such infested material is covered completely by lesser quantities of manure and trampled by livestock. On the other hand, all evidence shows that when infested cornstalks are only partially covered by the manure or are covered only 3 to 4 inches deep, many of the contained borers survive by crawling to the parts of the stalks not covered by the manure.

Horse manure, or manure in a heating condition, gave quicker and more reliable results than cow manure, even when infested cornstalks were covered completely by not more than 2 inches of manure.

FIG. 23.—Type of clean plowing required for effective corn-borer control. All cornstalks and trash are turned under cleanly and deeply

It should be emphasized that under ordinary farm conditions the large uneaten parts of corn fodder should be kept out of the manure, unless it is possible to work them deeply into the manure or to have the manure trampled by livestock.

PLOW CLEAN FOR CORN-BORER CONTROL

As a result of many field experiments, it has been determined that clean plowing under of infested cornstalks, stubble, and other corn remnants (fig. 23) is a very effective method of corn-borer control. Naturally this method is limited to soils that are in a condition to permit clean plowing and the preparation of a satisfactory seed bed for later crops before the corn-borer moths emerge.

It should be made plain that the effectiveness of plowing, from the standpoint of corn-borer control, depends upon turning under the

corn remnants and other trash so completely that none of it remains upon the soil surface. It requires also that the material plowed under shall not be dragged to the soil surface by later cultivation before the moths emerge, and that the soil surface be cultivated to close all large cracks and crevices.

The mere act of plowing under infested cornstalks, etc., does not of itself kill the borers contained therein. Most of the borers in such plowed-under material crawl up to the soil surface sooner or later. If the plowing has been done in a clean manner these loose borers can not find any shelter and soon perish as a result of exposure to the weather, or through destruction by their many natural enemies, which include birds, ants, ground beetles, and various insect parasites and predators. If, on the other hand, the plowing has not been done cleanly these loose borers, upon reaching the soil surface, encase themselves or bore into any fragments of corn husks, cornstalks (fig. 24), corn leaves, stubble, weeds, etc., that may be left on

FIG. 24.—Small piece of cornstalk left on soil surface, split open to show corn borer within. This borer was plowed under but crawled out and bored into this piece of cornstalk for shelter. The arrow points to the borer. This illustrates the necessity for clean plowing

the surface. With this protection, they are able to complete their development to the moth stage.

AVERAGE PLOWING METHODS MUST BE IMPROVED

To be effective as a means of corn-borer control, the plowing methods now commonly used in many parts of the areas infested by the corn borer should be improved. This plowing, which leaves many pieces of cornstalks, stubble, husks, weeds (fig. 25), leaves (fig.26), etc., on the soil surface is not an effective method of corn-borer suppression because such trash provides shelter for many of the borers which crawl to the soil surface after being plowed under.

Poor or ordinary plowing, therefore, does not control the corn borer and is in many respects worse than no effort whatever, because

a poorly plowed field (fig. 27) creates a condition which is very difficult to clean up by other methods.

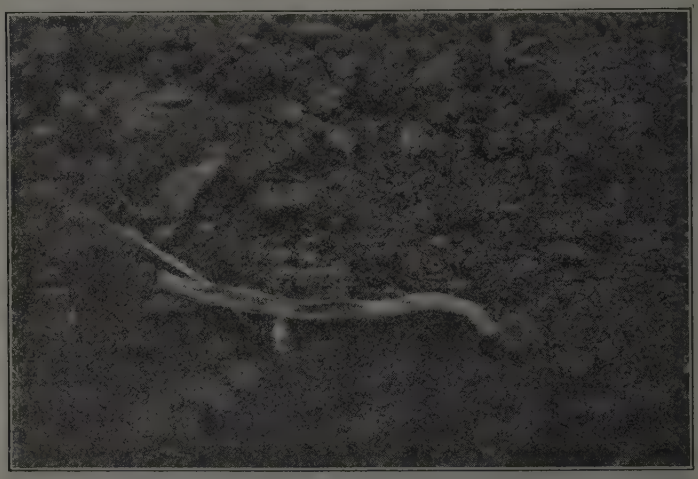

FIG. 25.—European corn borer in small piece of weed stem on soil surface of plowed field. This fragment was about 6 inches long. The arrow points to the corn borer

It is believed that the average plowing methods now applied to cornstalks or stubble can be greatly improved from the standpoint of corn-borer control. Field tests have shown that the skill of the plowman in doing a good job of plowing is as important, within reasonable limits, as the size or the type of plow used. A 14-inch bottom plow, equipped with attachments for covering trash, gave good results when properly adjusted. The new and specially designed 16-inch and 18-inch bottom plows recently placed on the market are well adapted for clean plowing and gave good results when used in standing cornstalks and stubble. Field experiments with these plows showed that with the aid of a rolling coulter of proper size, a jointer, and a chain, or with wires as hereafter described (fig. 28), all standing cornstalks and all trash could be covered

FIG. 26.—Small fragment of corn leaf sheltering corn borer on surface of plowed field. Leaf unrolled to show borer within

completely (fig. 23) without previous treatment. When using an 18-inch plow in ordinary soil, an 18-inch coulter is required. With this same plow in muck soil or soils of similar character a 24-inch coulter is necessary. With such equipment the stalks and trash may be turned to the bottom of the furrow so completely that the land can be prepared for later crops without dragging the turned-under material to the surface.

An effective attachment of three wires to aid in turning under trash is shown in Figure 28. A No. 9 galvanized or wrought-iron wire has given good results. The wires should be about 10 feet long, attached as shown in the illustration, with the other ends left loose. In operation the loose ends are caught by the furrow slice as it is turned over. In this manner the wires are held tightly to the top of

FIG. 27.—This type of plowing does not control the European corn borer, because the stalks left on the surface of the soil provide shelter for borers which crawl back to the surface after being plowed under

the furrow slice by the weight of the soil on the buried ends of the wires, and all trash is thus turned to the bottom of the furrow.

The choice of the plow to be used, the necessary attachments thereto, and the previous treatment, if any, of the stalks or stubble before plowing can be left to the judgment and experience of the plowman, provided it is kept in mind that the stalks, stubble, etc., must be turned under cleanly and not brought to the soil surface by later cultivation, as previously mentioned.

The results of experiments indicate that the depth of plowing for corn-borer control is not important, provided all infested material is covered completely to such a depth that it will not again be brought to the soil surface by later cultivation or weathering, to act as a shelter for the loose borers crawling on the surface. In order to insure proper coverage, however, and to limit the possibility of the

plowed-under material being again dragged to the soil surface, it is believed that plowing to a depth of at least 6 inches should be adopted whenever possible.

Experiments have shown that in the Middle West the time of plowing is not important as far as the actual destruction of the corn borer is concerned. If the stalks are plowed under in this area during the late summer or early fall, or in the spring, most of the borers contained in the stalks crawl to the soil surface soon after the plowing. If the stalks are plowed under in the late fall most of the borers remain inactive in the stalks all through the winter and then crawl to the soil surface in the spring after the soil warms up in April or May. In either case it is important that they find no refuse on the surface in which to hide.

FIG. 28.—An effective attachment of three wires to aid in turning under cornstalks and other trash. The wires are about 10 feet long and the ends are left trailing

POLING, RAKING, AND BURNING, FOLLOWED BY PLOWING, VERY EFFECTIVE

When the available plowing equipment is not sufficient to plow under entire cornstalks or high stubble completely it often is necessary to cut or pole down the stalks or stubble, rake them both ways of the field into windrows or piles, and burn such windrows or piles cleanly. The remaining parts may then be plowed under entirely.

It is recommended that this practice be followed in instances where for any reason a good, clean job of plowing can not be done without previous treatment of the bulk of cornstalks or stubble.

BURNING INFESTED PLANTS

Burning is naturally an effective method of disposing of infested cornstalks or other plant material which can not be fed to livestock

or plowed under cleanly. This method, however, has the disadvantage of not being a good farm practice from the standpoint of returning as much organic matter as possible to the soil. Nevertheless, the burning of cornstalks and other crop residues infested with corn borers seems justified and must be adopted when the material can not be effectively disposed of in any other manner.

The method of burning infested plants will naturally vary in accordance with the prevailing farm practice.

In case the corn is cut and shocked, the problem is comparatively simple, since any surplus shocks may be burned in position or, if necessary, hauled to a suitable location and burned, not later than June 1 of each year. This should include all cornstalks that have been used in building shelters for livestock, for thatching (fig. 29), windbreaks, and similar purposes, as well as surplus stalks stored

FIG. 29.—Wire corncribs thatched with cornstalks infested by the European corn borer; a source of reinfestation unless disposed of by burning or otherwise before moths emerge

for feeding purposes and cornstalks along ditch banks and field borders (fig. 30).

In cases where the ears are husked from standing stalks the problem of burning the stalks cleanly is more difficult. Even under these conditions, however, the main point to keep in mind is that all corn remnants should be fed, plowed under, or burned. If the burning of these standing stalks is considered the best solution of the problem under existing conditions, several methods of procedure are possible. The stalks may be cut at or close to the ground level with a corn binder equipped with a low-cutting attachment, with a "float," with a mowing machine, or with a hoe in the case of small fields in which such a method is practicable. As soon as they are dry the stalks should be raked into windrows (fig. 31), both directions of the field if necessary, and burned. The windrows should be burned cleanly, even though it may be necessary to resort to hand methods in raking stalks into the fires. Probably the simplest method available in most sections now infested by the corn borer is to break over or "pole down" the stalks with an iron rail or a heavy timber with

sharp edges, or a planker, while the stalks are brittle with frost during the winter or early spring. They should then be raked and burned, as mentioned previously.

FIG. 30.—Corn refuse and large weeds along ditch bank of cornfield. Such refuse provides shelter for the corn borer and should be destroyed

Many types of special tools have been used to cut or break off standing cornstalks in preparation for raking and burning. One of

FIG. 31.—Raking infested cornstalks into windrows, followed by burning. This is an effective method of corn-borer control if infested cornstalks are cut low, raked cleanly, and burned cleanly

the most effective devices observed consisted of a plow with a sharpened point. This sharpened plow was run beneath the surface of the

soil at a depth of about an inch and cut the cornstalks off at their base. Furthermore, the operator waited until a light rain had toughened the cut stalks to such an extent that the leaves, husks, and ends of the stalks did not break off during the process of raking the stalks into windrows. Then by waiting until the stalks had become thoroughly dry in the windrows a clean job of burning was done. After double disking this field not a trace of corn remnants could be found on the surface.

POLING, RAKING, AND BURNING MUST BE DONE CLEANLY

Although many field tests have shown that careful poling, or cutting, the stalks or high stubble, followed by raking and burning, resulted in the destruction of a very large percentage of the borers,

FIG. 32.—Hand picking of cornstalk fragments infested by the corn borer following a poor job of poling, raking, and burning. Clean raking and burning would have saved this expense.

an examination of many infested cornfields in the corn-borer districts of the Great Lakes section showed that this method as ordinarily practiced on farms frequently allowed a high percentage of the borers to escape destruction, unless it was followed by hand-picking (figs. 32 and 33) the remnants or by clean plowing. In fact, under many conditions in which a clean job of poling, raking, and burning can not be done, it seems necessary to follow this method by plowing the field in the manner previously recommended. Since hand picking is expensive and impracticable under large-scale conditions, it is obvious that in fields in which soil conditions or other considerations do not allow plowing before the crop is put in, unusual care must be taken in the process of poling, raking, and burning.

In order to emphasize the importance of disposing of small pieces of trash on the surface of infested cornfields, it should be stated that careful examinations of the surface of typical infested fields in

FIG. 33.—Piles of corn fragments, infested by the corn borer, picked from surface of field, following a poor job of poling, raking, and burning. Such piles are burned. There were estimated to be 1,300 borers per acre in the corn débris on the surface of this 70-acre field.

northwestern Ohio showed that an average of 14 per cent of the total borer population were left in small pieces of corn husks, leaves (fig. 26), weed stems, etc., which it was not possible to gather with the type of rake ordinarily used for such purposes.

FIG. 34.—Burning infested cornstalks or stubble with special burning outfit

SPECIAL BURNING MACHINES

Burning infested cornstalks or stubble while these are standing in the field (fig. 34), by the use of special burning machines, is an effective method for destroying the corn borer.

The oil-burning outfit (fig. 35) used by the Bureau of Entomology consists of a 600-gallon steel tank, and a triplex bronze pump capable

of developing a pressure as high as 1,000 pounds to the square inch. Kerosene or a clean, light fuel oil, with a specific gravity not greater

FIG. 35.—Oil-burning outfit built especially for pumping oil to the burners. This pump will supply two portable burners, or from four to eight hand burners

than 0.809 (43° Baumé) is used as fuel. The oil is forced by the pump through oil-pressure hose to specially constructed burning

FIG. 36.—Portable burner working in field infested by the European corn borer

carriages (fig. 36). These portable carriages are equipped with several nozzles. As the oil leaves these nozzles under high pressure it

is lighted and creates an intense heat and flame, reaching a temperature of about 1,400° F. This flame serves to consume all cornstalks or other plant material in its path or to heat such material to such a degree that practically all of the borers contained therein are killed.

BURN CORNCOBS AND WATCH CORNCRIBS

The process of shelling corn does not ordinarily kill the borers contained within the cobs. It becomes necessary, therefore, to burn all cobs in corn-borer-infested districts not later than June 1 of each year.

All shelled corn intended for shipping outside the infested area should be free from portions of cobs, because such portions are likely to harbor the borer in case the ears originated in badly infested fields.

Corn originating in badly infested fields (fig. 10) should be shelled not later than June 1 of each year and the cobs burned. When im-

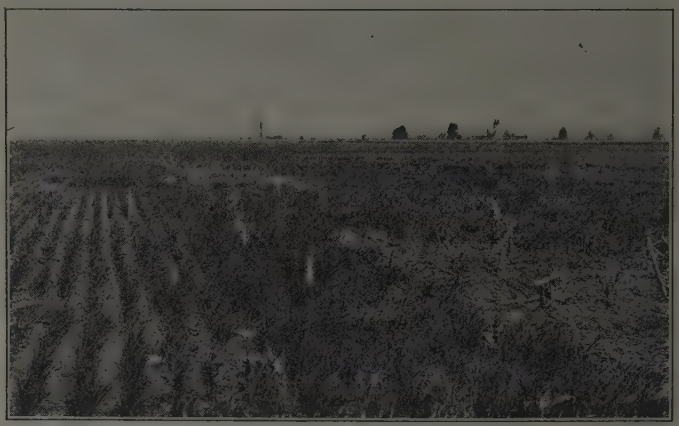

FIG. 37.—Field of high corn stubble disked to oats without previous treatment. This practice must be stopped in areas infested by the European corn borer

practicable to shell such corn before June 1, it should be placed in a tight compartment or covered by wire screen, at least 12 meshes to the inch, to prevent the escape of emerging corn-borer moths.

DISKING CORNFIELDS IS NOT AN EFFECTIVE CONTROL

Field tests in infested cornfields of the Middle West have shown that disking cornstalks or high stubble in preparation for the seeding of small grain or other crops is a very objectionable practice from the standpoint of corn-borer control. This practice not only allows a very high percentage of the borers to survive, but the shade furnished by the growing grain affords protection from the weather to the borers contained in the trash left on the soil surface. (Figs. 37 and 38.)

Extensive field experiments in disking cornstalks or corn stubble, as ordinarily practiced, in preparation for the seeding of small grain,

have shown the impossibility of securing anything like adequate corn-borer control by this method. (Fig. 39.) Even though such

FIG. 38.—Living corn borer near base of corn stubble in disked field. Stubble cut open to show borer inside. The arrow points to the borer

fields were thoroughly disked as many as six times, there were large quantities of large and small pieces of stalks on the soil surface.

FIG. 39.—Typical field of high corn stubble. This practice of high cutting must be stopped in areas infested by the corn borer, unless such stubble is disposed of by clean plowing or other methods, before the moths emerge

On an average, only about 12 per cent of the borers originally contained in the stalks or stubble had been killed.

Tests in rolling such fields of stalks or stubble with various kinds of rollers, before and after disking, showed very little benefit from their use. The same was true of the various cultipackers and harrows ordinarily used to prepare fields for seeding.

It is apparent that, regardless of any necessary change in farm practice, the disking for small grain or other crops on cornlands infested by the corn borer must be discontinued if the corn borer is to be held in check and widespread commercial loss prevented. Where unavoidable, this practice should be limited to fields in which the operations of cutting or breaking off the stalks at the ground level and completely disposing of them, together with all trash, by burning or otherwise, have been carefully carried out.

CORN STUBBLE AN IMPORTANT SOURCE OF REINFESTATION

Mention has been made previously of the large number of corn borers left in the stubble (fig. 39) of infested cornfields. The percentage of the total borer population left in the stubble usually depends upon the height of the stubble left after cutting, the date the stalks were cut, the character of the weather, and the stage of development of the plants when cut. Thus from cornstalks cut during the middle of September about 7 per cent of the total number of borers originally present in the field remained in 6-inch stubble, about 17 per cent remained in 12-inch stubble, 20 per cent in 15-inch stubble, and 23 per cent in 18-inch stubble. Cornstalks cut during the early part of November showed about three times as many borers in stubble of any given height as in stubble from cornstalks cut during the middle of September.

Careful field examinations have shown that from about 15 per cent to nearly 40 per cent of the total number of borers originally present in the field are ordinarily left in the stubble of cornfields in the Great Lakes section. In 1926 the number of borers left in each acre of corn stubble in this section varied. The average range was from 793 to 944 borers. The stubble in these fields ranged from about 4 inches to nearly 23 inches in height.

It is plain that if the corn is to be cut, it should be cut as low and as early as possible and that all high-cut stubble should be disposed of by the recommended control methods.

CONTROL METHODS THAT MAY BE USEFUL UNDER SOME CONDITIONS

TIME OF PLANTING AND CHOICE OF VARIETIES

Experiments and field tests in the one-generation corn-borer areas of the Great Lakes section have shown that field and sweet corn planted during April or during May have usually sustained the worst corn-borer infestation while, on the contrary, plantings made after the first week or 10 days of June have suffered very little injury from the pest in an ordinary season. It appears, therefore, that in areas in which the corn borer is abundant the late planting of field or sweet corn is an important help in avoiding severe injury by the pest.

This practice is not recommended, however, in lightly infested sections because the late planting of the field or sweet corn varieties

now commonly used is likely to result in decreased yields, even though the corn matures properly.

None of the types, varieties, or strains of corn thus far tested has shown any indication of real immunity from corn-borer attack. However, the varieties with large stalks have shown a greater resistance to severe corn-borer damage than varieties with small stalks. This applies to field corn (dent and flint), sweet corn, pop corn, and silage or fodder corn. The greater resistance to corn-borer injury shown by the varieties with large stalks, as compared with varieties having small stalks, other conditions being equal, is due apparently to the greater size and stiffness of the large stalks which enables them to withstand a certain amount of corn-borer injury without great loss. Under conditions of severe corn-borer infestation, however, as many as 25 to 40 or more borers are found, on an average, in each plant in the fields. Under these circumstances even the large-stalked varieties have been so seriously injured by the corn borer as to result in a partial or complete loss of the crop.

TRAP CROPS

Attention has been called to the fact that the earliest-planted fields of corn, particularly sweet corn, usually suffered the heaviest corn-borer infestation in any given area. This naturally suggested the use of a small area of very early-planted sweet corn in fields intended for a main crop of field corn or late-planted sweet corn, to attract many of the corn-borer moths and thus act as a trap crop. Such trap crops of course must be destroyed, or used for fodder, early in the season. Actual attempts to apply the trap-crop method of control under field conditions, however, have thus far failed to show reliable results. It appears that trap crops can not be depended upon as a corn-borer control method, but in a favorable season they attract many moths which would otherwise lay their eggs on the main crop of corn.

INEFFECTIVE MEASURES

INSECTICIDE APPLICATIONS

Because the corn borer passes most of its life inside the plant, very little chance is offered for killing it with any of the poison sprays, poison dusts, or other insecticides now in use. A great variety of sprays, dusts, fumigants, and similar materials have been tested in an effort to find some treatment that could be given to growing corn as a protection against the corn borer. The results were not effective, however, so none of the insecticides tested can be recommended for general use. Nicotine dusts containing 2 or more per cent of free nicotine directed against the newly hatched borers gave encouraging results in limiting injury to valuable crops of corn. The possibility of developing more effective insecticides for the corn borer is still under investigation.

PASTURING WITH LIVESTOCK

The fondness of hogs for soft-bodied insects is well known, but field tests in turning hogs into cornfields which were severely infested

by the corn borer showed that the hogs would not eat the corn borers contained in the stalks or the borers crawling loose on the surface of the soil.

Goats were turned into infested cornfields in an attempt to test the well-known ability of these animals in cleaning up plant remnants. In these tests, however, the goats did not eat the large, hard portions of the cornstalks, which usually contain the greater part of the corn borers. Not more than a fourth of the borers were destroyed by these animals.

TRAP LIGHTS AND ATTRACTIVE BAITS

One of the oldest methods used in attempting to control destructive insect pests was the trap light. The moths were attracted to the light and then destroyed. Although extensive efforts and much money have been expended in attempts of this nature, the use of trap lights as a method of control has never been successful in the case of any insect pest.

The trap-light method, however, was given a very thorough test in the course of the European corn-borer investigations. Repeated observations with many types, kinds, and colors of lights showed that the number of corn-borer moths attracted to such lights comprised less than 1 per cent of the total corn-borer moths in the vicinity. It is plain, therefore, that this method has no value as a method of corn-borer control.

METHODS OF CONTROL IN NEW ENGLAND

The methods of controlling the corn borer in New England are practically the same as those which have been described for the Middle West. In the New England section, however, the corn borer is found commonly in such a great variety of vegetables, field crops, flowers, and weeds, in addition to corn, that the remnants of these other plants must be included in clean-up operations. Particularly important are the large areas of weeds growing in waste lands. Such areas must be cleaned up by burning while the plants are dry or by the use of weed killers when the plants are in a green, growing condition.

In this area, also, late-fall plowing has been found to be more effective than early fall or spring plowing because the great majority of the borers which are plowed under during the late fall perish in the soil in this two-generation area of corn-borer infestation. The small number that do succeed in crawling to the soil surface are subjected to the same handicaps that have been described as occurring in the Middle West.

CATERPILLARS OFTEN MISTAKEN FOR THE EUROPEAN CORN BORER

Several kinds of common, native caterpillars, "worms," or borers are often mistaken for the European corn borer, thus causing needless alarm. Some of these are similar in appearance to the European corn borer, but others, although very different in appearance, cause damage that often resembles the injury caused by it.

It is important that all corn growers be on the lookout for the European corn borer. Therefore, when any specimens of worms,

caterpillars, or borers suspected of being the European corn borer are found, they should be placed in a tight tin or glass container, together with a few strips of crumpled paper, and sent to the nearest corn-borer laboratory. Such laboratories are located at 17 Division Street, Silver Creek, N. Y.; at Sandusky, Ohio (address P. O. box 976); at Monroe, Mich. (address 308 West Elm Street); at Toledo, Ohio (address 615 Front Street); and at 10 Court Street, Arlington, Mass.

THE CORN EARWORM

On account of the similarity of the damage it does to the ears of corn, the corn earworm [13] (fig. 40) is very often mistaken for the corn borer. This insect is also known as the cotton bollworm, tomato fruit worm, and tobacco bud worm.

The corn earworm, however, is not a true boring insect and usually confines its damage to the silks and kernels of the ear, whereas the corn borer not only feeds habitually upon the silks and kernels of the ear, but also bores into the cob. Unlike the corn borer, the corn earworm does not bore into the stalks, although if the ears have not developed on young plants it often feeds upon the leaves and in the growing tip or "bud" of the plant. This injury sometimes results in broken-over tassels which at a distance resemble corn-borer damage, but close examination will show that these tassel stems have not been tunneled. This characteristic serves to distinguish such injury from that of the corn borer. During the late fall, winter, and early spring the corn earworm is never present in the ears of corn or in the stalks, whereas the corn borer may commonly be found in ears and stalks of corn at this time in areas in which the insect is numerous.

FIG. 40.—Three corn earworm larvae, seen from the side, showing color types: Upper larva, green; middle one, rose colored; lower one, dark brown. Not quite twice natural size. (Quaintance and Brues)

The caterpillars of the corn earworm are about 1½ inches long when full grown and vary greatly in color, ranging from tints of green, pink, rose, yellow, and brown to almost black. They may be beautifully striped, or spotted with brown, black, or yellow along the side and back, or they may be entirely free of stripes or spots. In appearance they can be readily distinguished from the corn borer by the fact that they are nearly twice the size of the latter. The hairs arising from the black tubercles, or warts, on the back of the earworm are much longer and stouter than those arising from the brown tubercles on the back of the corn borer. The castings of the earworm are coarse, wet, and foul, while those of the corn borer are

[13] *Heliothis obsoleta* Fab.

more finely divided and usually dry. The earworm is widely distributed throughout the country.

THE STALK BORER

The stalk borer [14] (fig. 41) is often very numerous during the early summer in some sections of the country. It works habitually within the growing tip (heart) and stalk of young corn, and is frequently mistaken for the European corn borer on account of its habit of boring into the cornstalks. It also bores into the stalks, and infrequently into the fruit of several other cultivated crops and flowers and in weeds.

The young caterpillars of the stalk borer are very easy to distinguish from those of the corn borer, as they bear a dark-brown or purple band around the middle of the body, and several conspicuous brown or purple stripes run lengthwise of the body. The corn borer does not possess these conspicuous bands or stripes. As the stalk borer becomes full grown, however, these bands and stripes disappear and the color becomes plain creamy white or light purple, and only inconspicuous markings are visible. The full-grown stalk borer is slightly over an inch long and is much larger throughout than the corn borer. It is never found in cornstalks during the winter.

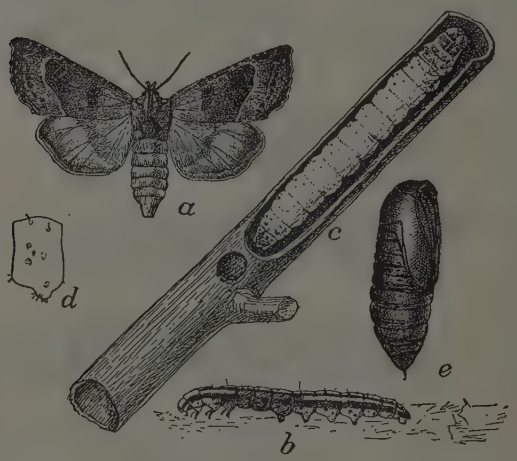

FIG. 41.—Stalk borer: *a*, Female moth; *b*, half-grown larva or borer; *c*, full-grown larva in injured stalk; *d*, side view of segment of abdomen of full-grown larva; *e*, pupa. All somewhat enlarged. (Chittenden)

THE SMARTWEED BORER [15]

The smartweed borer is very frequently found in corn during the fall, winter, and spring. The appearance and work of this native borer resemble those of the European corn borer so closely that it is very difficult to distinguish between them. The smartweed borer usually feeds within the stems of smartweed,[16] but it commonly bores into the stalks of corn and other plants when seeking winter quarters.

[14] *Papaipema nebris* Guen., form *nitela* Guen.
[15] *Pyrausta ainsliei* Heinrich.
[16] Species of Polygonum.

It is known to be very numerous throughout the eastern part of the country, and many reports of European corn-borer occurrence have been due to the presence of the smartweed borer.

The caterpillars of the smartweed borer are about three-fourths of an inch long when full grown, slightly smaller than the corn borer, and less robust. They are always slate colored or gray when full grown, and in the living state they bear a very fine, faint line of darker color running along the middle of the back, whereas in the living corn borer this line is decidedly broader and very conspicuous. Except for these differences, and one or two microscopic distinctions which are discernible only to an entomologist, these two kinds of

FIG. 42.—The larger cornstalk borer. Natural size

borers have the same appearance when full grown. On hatching from the eggs the small caterpillars of the corn borer have black heads, while those of the smartweed borer have pale amber-colored heads.

THE LARGER CORNSTALK BORER[17]

In the Southern States, and especially in the South Atlantic States, the larger cornstalk borer (fig. 42) is a common enemy of the

[17] *Diatraea zeacolella* Dyar.

corn plant, and owing to its habit of tunneling in the stalks of corn it may be easily confused with the European corn borer. The larger cornstalk borer, however, does not bore into the ears of corn, whereas this habit is characteristic of the corn borer. This southern pest habitually overwinters only in the rootstock of the corn, whereas the corn borer not only winters in the stubble of corn but may also be found in the stalks and ears of corn and in the stubble.

The caterpillars of the larger cornstalk borer are of two types—a summer form and a winter form. The summer form, when full grown, is about 1 inch in length, with a dirty white body thickly dotted with round or irregular dark spots, each of which bears a short dark bristle. The head region is brownish yellow. The winter form differs from the summer form in that the caterpillar is more robust and is slightly shorter, while the spots referred to above are nearly the same color as the body. In the Gulf strip and on the Mexican border two distinct but very similar and closely related caterpillars [18] may attack corn.

SUMMARY OF CONTROL METHODS

The main effort at control of the corn borer in the Middle West should be directed toward the disposal of corn refuse.

Large-stemmed weeds or grasses growing in or along the edge of badly infested cornfields must also be destroyed.

Infested plants may be disposed of through any one of the following methods or by a combination of such methods:

(1) Feeding to livestock direct from the field, or as silage, or as finely cut or finely shredded material.

(2) Plowing under cleanly.

(3) Burning completely.

Each field presents a separate problem. In any case the clean-up method adopted will vary according to the farming practice used. The important thing to remember is that all corn remnants must be disposed of before the corn borer changes to the moth, or flying stage.

For the sake of safety the clean-up should be completed by May 1 of each year.

In fields which can not be plowed, or otherwise handled effectively in the spring, special effort should be made to dispose of all corn remnants during the fall.

In case the corn is to be cut, it should be cut as low and as early as possible. Special low-cutting attachments for corn binders may be purchased for this purpose.

If corn is to be cut by hand, a short-handled heavy hoe should be used because this permits low cutting without undue exertion.

In case infested cornstalks are fed direct to livestock without previous cutting or shredding, the uneaten parts should be destroyed unless trampled deeply into manure.

Increased use of the silo and husker-shredder machines is recommended.

If plowing is to be effective in destroying the corn borer all trash must be turned under completely so that plowed-under material may not be dragged to the soil surface by later cultivation before the moths emerge.

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[18] *Diatraea saccharalis* Fab. and *Diatraea grandiosella* Dyar.

Clean plowing deprives borers of their natural shelter when they crawl to the soil surface after being plowed under.

Average plowing methods must be improved sufficiently to insure that all cornstalks and trash are turned under completely.

Neither depth of plowing nor time of plowing is important for corn-borer control if a clean job is done and material is not afterward dragged to the soil surface.

In case the available plowing equipment will not handle standing cornstalks or high stubble, they should be cut or broken off at the ground level, raked both ways of the field into windrows, and burned. This reduces the bulk of the material to such an extent that the remaining parts can then be plowed under cleanly.

Breaking or cutting off standing cornstalks at the ground level, followed by clean raking into windrows or piles, and clean burning, are very effective methods. They may be made more effective if the remaining trash is plowed under cleanly.

Before June 1 of each year burn all cornstalks that have been used for building shelters for livestock, for thatching, and for windbreaks, and similar purposes. This should also include surplus stalks stored for fodder and all stalks in and around barnyards and feed lots.

Keep all portions of corncobs out of shelled corn intended for shipping to points outside the infested areas.

Corn from badly infested fields should be shelled not later than June 1 of each year and the cobs burned. Ear corn from such fields should be kept in a tight compartment or covered by fine-mesh wire screen to prevent the escape of the emerging moths.

Disking cornstalks or high-cut stubble is an objectionable practice in fields infested by the corn borer, because it leaves abundant shelter for the borers.

Corn planted late (after June 10) usually escapes severe damage by the corn borer, and such late planting may be adopted as an emergency measure in areas where the pest is numerous.

Trap crops are not reliable as a method of corn-borer control.

Poisons, trap lights, attractive baits, or pasturing infested cornfields have not been effective in controlling the corn borer and are not recommended.

Insect parasites may eventually help to control the corn borer, but several years must elapse before any appreciable results may be expected from this source.

Control of the corn borer depends upon community-wide effort. The corn growers must help one another. Corn-borer moths fly from field to field. Compulsory clean-up laws are necessary to secure the full cooperation of all concerned.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

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